VOLUME XXIV NUMBER 6 WHOLE NUMBER 195

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

DEVOTED TO THE ADVANCEMENT OF ASTRONOMY AND ALLIED SCIENCES

EDITOR
C. A. CHANT
University of Toronto, Toronto

ASSOCIATE EDITORS
J. S. PLASKETT
Director of the Dominion Astrophysical Observatory, Victoria, B.C.

J. PATTERSON
Director of the Meteorological Service of Canada, Toronto

R. MELDRUM STEWART
Director of the Dominion Observatory, Ottawa

PUBLISHED MONTHLY
(Ten numbers per year)

July-August, 1930

PRINTED FOR THE SOCIETY
TORONTO: 198 COLLEGE ST.

THE JOURNAL

OF

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

VOL. XXIV, No. 6 JULY-AUGUST, 1930 WHOLE No. 195

PAGE

Articles

John Andrew Paterson (with Plate VIII) - - - *W.B.M.* 249
The Universe as a Whole - - - - - *A. S. Eve* 251
On the Periods of the Stars of the Mira-Type - *Rev. Fr. Lause* 271
The Wolf-Rayet Stars (with Plate IX) - - *C. S. Beals* 277
Planet X—Lowell Observatory Observation Circular *V. M. Slipher* 282

Review of Publications

L'Ancienne et la Nouvelle Théorie des Quanta (E. Bloch)—Astronomy (R. H. Baker) - - - - - - - - 285

News and Comments

News of Canadian and other Astronomical Work - - *REDeL* 287

Notes and Queries

Open Tube Construction for Telescopes—Calendar Reform—The Date of Easter—An Astronomer Draws the Line—An Agricultural Observation - - - - - - - - *C.A.C.* 288

Meetings of the Society

At Ottawa—At Toronto - - - - - - - - - - 293

Upon request, made previous to publication of article, contributors will be supplied free either with fifty copies of the issue containing the article, or with the sheets containing the article attached to a printed cover. If separate reprints are desired the cost will be as follows:

	4 pp.	8 pp.	12 pp.	16 pp.	20 pp.	24 pp.
50 copies	$3 50	$5 50	$ 9 50	$10 00	$13 00	$10 00
100 copies	4 00	7 00	10 00	11 00	14 00	18 00
200 copies	4 50	8 00	11 00	12 00	15 50	20 00

Covers, extra, 50 copies, $1.50; 100 copies, $2.00; 200 copies, $2.50.

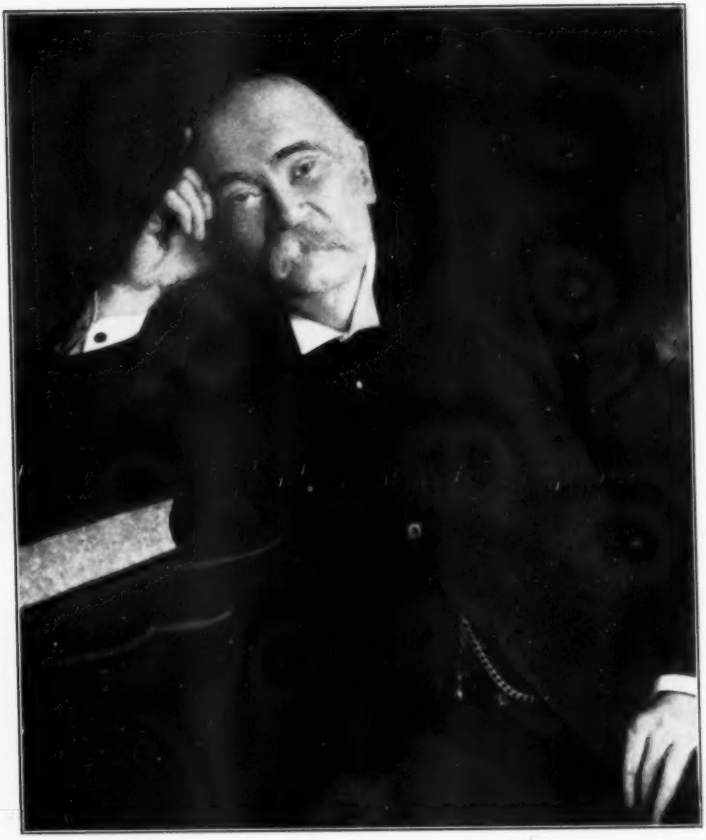
Business correspondence, remittances, etc., should be addressed to H. W. Barker, Treasurer of the Society, 198 College Street, Toronto.

Communications regarding Library matters should be addressed to the Librarian.

$2.00 per annum. Single numbers, 25 cents.

Subscription to the JOURNAL is included in membership fee.

PLATE VIII



JOHN ANDREW PATERSON
1846-1930

THE JOURNAL
OF
THE ROYAL ASTRONOMICAL SOCIETY
OF CANADA

VOL. XXIV, No. 6 JULY-AUGUST, 1930 Whole No. 195

JOHN ANDREW PATERSON

With Plate VIII.

In the passing of John Andrew Paterson, K.C., M.A., F.R.A.S.C., the Royal Astronomical Society of Canada loses one of its oldest and most valued members.

Born at Stornoway, Isle of Lewis, in 1846, he came to Canada with his father, the Rev. John Paterson, while yet in his boyhood. His early education was received from a private tutor, and then he attended Upper Canada College—where he headed his class in 1861. He subsequently joined the staff of the College as teacher in the department of mathematics. From thence Mr. Paterson passed to the University of Toronto, making a brilliant record as a student, regularly attaining first class honours in mathematics, classics, and English. He graduated with the degree of B.A. in 1866, and received the degree of M.A. in 1867. He entered the Ontario Law School and was called to the bar in 1873. He was created a King's Counsel in 1902. The practice of his profession was marked by dignity, energy, and convincing argument.

It was as a student of astronomy, however, that Mr. Paterson was best known to the members of this Society.

The first meeting of the Astronomical and Physical Society of Toronto (afterwards the R.A.S.C.), was held on the 25th February, 1890, and Mr. Paterson was elected a member in the following December. His first paper, "Before the Beginning", was read before the Society in December, 1892, when he reviewed Croll's

theory of stellar evolution. He was elected a Vice-President in January, 1892, which office he held until 1895, when he became President, and was re-elected to the latter office the following year.

Mr. Paterson delivered the annual address in 1894 and 1895, and the Presidential addresses for 1897 and 1898, and contributed to the JOURNAL of the Society a series of papers on the astronomy of Shakespeare, Milton, and Tennyson, (1909).

In 1908 he presented a paper on "The Apex of the Sun's Way", and in 1910 one on "Art and Astronomy". Then followed a series of biographical sketches: Simon Newcomb: his Life and Work, 1913; Sir Robert Ball, 1916; The Greatest Natural Philosopher (Newton), 1917; Sir David Gill, 1919; Percival Lowell: his Life and Work, 1922; Edward Emerson Barnard: his Life and Work, 1924. Mr. Paterson's literary style and happy appreciation of these great men made his papers enjoyable to hear and pleasing to read afterwards.

Until recent years he was a regular attendant at the meetings and was active in discussion. The Society owed him much in the days when it was contending with the disadvantages of limited finances, and inadequate accommodation. Mr. Paterson contributed his full share of that enthusiasm, and love of knowledge which surmounts all obstacles. He died on the 13th of May at the ripe age of 84 years, and will ever be remembered by his fellow students in astronomy with affection and esteem.

W.B.M.

THE UNIVERSE AS A WHOLE[1]

By A. S. Eve

In Nature's infinite book of secrecy
A little I can read.
—*Antony and Cleopatra.*

Thinking Cosmically

Most men to-day are engrossed in some one particular profession or occupation that may involve monotonous drudgery, or may require special skill, technical knowledge, long experience and, more rarely, profound thought.

But it is doubtful if any group of men, except perhaps a few philosophers, is engaged in fitting together the jig-saw or patchwork puzzle of the multitudinous discoveries and theories of all our diverse branches of knowledge. Thought is thus divided into water-tight compartments, between which the communications are blocked.

Indeed, the further question arises whether the different parts of the puzzle will, in the present state of our knowledge, fit together at all; whether the gaps and misfits are not too wide and too great to permit of the undertaking. It is pertinent to remark that many of the great advances to-day are made by those who are fortunate and able enough to be expert in two subjects, for example, in physics and in physiology, or in mathematics and physics, or in physics and chemistry, or in physics and philosophy. Borderlands are prolific.

There is further difficulty in finding a man with a sufficiently catholic taste to consider all the realms of knowledge as a unity. Who indeed is equipped mentally for such a giant's task? Who can say nowadays with Bacon that he "takes all knowledge for his province"?

Certainly not the present writer! The fitness rather rests with the audience, for the Royal Society of Canada consists of men carefully selected for their achievements, as authors, poets, histor-

[1]Presidential address before the Royal Society of Canada, given on May 20, 1930.

ians, statesmen and as savants of every branch of natural science, the very list of which it would be tedious to recite. These men, too, belong to at least two types of Western European civilization, crudely summarized as English and French, including our inheritance from Greece and from Rome.

Perhaps then we are justified in following the advice of Fitzgerald, "To think cosmically," and to contemplate the universe as a whole.

The Framework of the Macrocosm

We find scattered through a vast region, nebulae, stars, planets, moons, comets, meteors, dust, gases and their radiations, with the main masses, the stars, far apart compared with their size, dominated by a mutual attraction, all in motion with respect to each other. There is there no such thing as rest. All these stars move with velocities ranging from a few miles a second to a few hundred miles a second. There is no suggestion of a very high gravitational potential; in simpler words, we see no evidence of an infinite, but rather of a large finite amount of matter in the universe.

Between these bodies there exists, or our intelligence infers from experience, a space approximately Euclidean, where the three angles of a triangle certainly do equal two right angles very nearly indeed.

This space has remarkable physical properties inasmuch as waves of a common nature pass swiftly in all directions freely, without interfering with one another's progress, differing, however, in wavelength, and all having the well-known high speed of light. This velocity appears to be one of the great constants of nature, which may be regarded not as relative, but as independent of the velocity of the source and of the speed of the observer. Space, then, is the region or vehicle of radiant energy. Since we know, or conjecture, that all matter is but one form of energy, we can estimate energy in terms of mass, and we may even quote the price of radiant energy in pounds in place of kilowatt-hours, and calculate the quantity received by the earth from the sun. The price is high and the quantity large. The earth receives from the sun about 160 tons

of sunlight a day, to a value of 500 million dollars a pound, so that our power bill amounts to 150 million million dollars a day, reckoned on the basis at which we have to buy our electricity in Montreal. This power bill is, of course, never presented, and our powerhouse, the sun, has been running effectively and regularly for at least ten thousand million years, and is likely to run, bar unforeseen accidents, for as many years at least in the future. We will postpone for the present the question of its closing-down!

This great space through which radiant energy passes may be regarded as empty or, inasmuch as it has the wonderful property of transmitting power, we may consider it as a physical entity, deem it worthy of a name and continue to call it ether, remembering always that in practice we give names to those things which have observable properties or distinguishable attributes. Apparently we must entirely divest our minds of all material ideas when we speak of the ether, but this will trouble us less and less as we continue to strip matter itself more and more of material attributes, and focus our attention on the less palpable manifestation of energy. Not that it is suggested that the word spiritual would at all help us in our idea of ether, nor can we find any warrant in fact, so far as present knowledge and experience seem to go, that the ether is the seat of psychic forces of a non-physical character. Any confusion between these ideas is at present the reverse of helpful, but even if the properties of the ether are one thing, and the properties of matter another, yet the linkage between them is so intimate that it may be that matter is merely a local singularity or peculiar structure of ether, as Sir Joseph Larmor and others have suggested.

At present it is still convenient to think of the universe as consisting, physically, of matter and of ether, or, if you please, of two different forms of energy, matter and radiation alike passing through space.

Space

If, as is the fashion to-day, we are relativists, we can believe that our space is finite but unbounded, and we are at liberty to agree with Silberstein that no distance greater than nine million

light-years is measurable in our universe. This leaves ample room for most of us, but it may be that some astronomers will feel themselves sadly cramped in so narrow a space, and indeed they now speak of distance exceeding a hundred million light-years.

To some degree it exalts the importance of each individual to realize that each one is the centre of his own universe wherever he be, and however fast he may move. Every man has his own ether, just as every man has his own rainbow. All the signals of nature which we receive by our senses and interpret by our minds are, of course, for each individual.

Speculations as to space and ether have a powerful fascination, but our actual knowledge is summed up by such ideas as Faraday's lines and fields of force, and more precisely by Maxwell's equations for electromagnetic fields. It was the effort to verify the truth of these equations which led Hertz to discover wireless (or radio) waves which enter to-day so largely into human life and experience.

The Microcosm

As we find that the universe may be bounded in its size as regards greatness, so we may ask whether there is any limit in the other direction, whether there is any limit as to the possible smallness of an entity, and although the time is not yet ripe to speak definitely on this question, yet we shall see shortly that there may be some limitation of the kind which I have suggested.

First let us, however, return to our suns, planets and moons, and realize that they are all made out of the same stuff, and of the very same elements with which we are familiar on this earth: This common material suggests, does it not, a very thorough mixing together in the past? The stars, each one of them, go through a regular prolonged stage of evolution, so that a glance at a star's spectrum, taken with telescope and prism, immediately informs the trained observer whether that star is in glorious growth, comfortable middle age or finally in the autumn of life or senile decay. Those stars which have reached their winter may be invisible to us, dark stars whose only chance, and that exceedingly remote, of a continuancy of activity is a collision with a travelling neighbour.

The material of the universe everywhere consists of ninety-two elements, and it is now known that there remain only two or three to be discovered, unless there are some heavier than uranium. These elements are the bricks of which the great edifice is composed throughout. They exist rather permanently as atoms, except in one great group of radioactive atoms, which spontaneously disrupt and become new atoms. Some of the elemental atoms have also been deliberately broken up, by careful design, as when Rutherford knocked hydrogen nuclei out of nitrogen, using alpha particles of radium as his Big Bertha or Roaring Megs. This control of atoms and their behaviur tells a very different story from the nineteenth century idea of hard, elastic, everlasting and indivisible atoms.

Atoms are wont to link together by bonds invisible and unknown (probably electromagnetic) and to combine into molecules, sometimes simple, and at other times, as in vegetables and animals, of appalling complexity. The simplest plant is a complex and marvelous chemical factory, which can also give birth to other similar factories! In the simpler cases it would at first appear probable that we could say—a molecule of water consists of two atoms of hydrogen and one atom of oxygen. We know the properties of both these constituent gases, therefore we can deduce the properties of the water molecule, and can foretell all the chemical and physical behaviour of ice, water and steam. I need hardly tell you how immensely short we fall of this achievement at present, yet it is a perfectly reasonable goal towards whch to strive. The matter is of such profound philosophical importance that it may be wise to dwell on it longer. The behaviour of the hydrogen atom is well known, but is it possible to deduce the properties of the hydrogen molecule, which is two atoms in close partnership? Here we have the most direct and simple problem of physico-chemistry, and yet it turns out to be terribly complex; indeed men are spending a large part of their lives on such apparently simple problems. It seems that from two simple entities there is created, or there evolves, a quite new and different complex or entity. Surely there is some satisfaction to the biologists in this situation! We may use the dubious phrase "creative evolution", but the wonder is not that

new forms arise; the larger mystery is how species are preserved, and how it is possible for offspring remotely to resemble their parents and ancestors!

To return to the molecules—after formation they are usually in a dynamic state, with their atoms oscillating to and fro, or revolving around one another, or both. The molecules may at the same time be rushing about with the velocity of bullets as in a gas, frequently colliding and rebounding, or they may jostle one another about in that crowded state we call a liquid, of which motion there is good evidence in the Brownian movement.

Yet again the molecules may, like men in a well-drilled army, fall into rank after rank of orderly arrangement so that there is a crystal, coherent, solid! The study of crystals has occupied, and is occupying, the lives of many of the ablest men in the world. In the great harmony of crystal arrangement there is to the human mind a satisfaction found elsewhere perhaps only in mathematics and in music.

Atoms and Electrons

Hunting further in the microcosm we find physicists restless in the pursuit of the interior constitution of the atom. The genius of J. J. Thomson, Rutherford, Moseley, Bohr and others, has drawn back the veil even in the lifetime of most of us, so that we find the bulk of the weight, mass or substance of an atom concentrated at the very nucleus or inner citadel, as a positive charge of electricity, this nucleus being small indeed compared with the whole atom. Around the nucleus we had a most satisfying picture or model of a swarm of electrons from one to ninety-two, according to the number of the atom, going swiftly around in elliptic orbits somewhat as planets go around our sun, with the most disconcerting added behaviour that these electrons could leap from one orbit to another according to well-conceived plan or rule, totally at variance with all our previous knowledge of how well-ordered bodies should behave. Hence the great quantum theories which so greatly perturb old-fashioned physicists, who have to face a revolution in their electrodynamic conceptions when they endeavour to apply them to

the constituent parts of an atom. It is curious to note that the principle of relativity has greatly attracted the attention of the thinking public, while the far greater *bouleversement* of quantum mechanics has hardly yet received attention.

At any rate, in place of the ninety-two elements in the universe, we enthrone two and only two physical entities—protons and electrons—together with the radiations or electromagnetic waves which pass through space between them, for every atom is both a wireless broadcasting station and also a wireless receiving station between which energy exchanges take place only in definite "lumps", each lump, bundle or quantum strictly proportional to the frequency transmitted; in other words, the illusive action is strictly atomic; or the ultimate "energy-time" is indivisible, a real atom. This sublimely simple electronic theory of the universe is now the fundamental common stock of all physicists, and provides sufficient and reasonable foundation for all purely physical phenomena. Yet it has been realized that the picture is too crude, and that there is either a limit to our perception or a limit set by nature herself, so that authorities like Bohr, Heisenberg, Schrödinger and Dirac assure us that we must abandon all models, all diagrams, all our large-scale experience, whether suns, planets or billiard balls, and admit that the microcosm does *not* resemble the macrocosm: that of the electron we can never say, Lo! here it is! It has gone before we say it. To mention its speed is to lose its position, or to indicate its place is to confound its speed. This is profoundly disconcerting to those, who, like the writer, have been brought up to revel in models and lines of force and diagrams. Only mathematical equations, complicated enough, expressing wave motions, can now describe the behaviour of atoms and electrons. Only the probability can be calculated of the place or motion of individual electrons. The physicist stands as actuary calculating the statistical behaviour of a crowded and confused entity. That there will be a reaction to these tendencies is most probable, perhaps led by plain-thinking Anglo-Saxons; but whether the reaction will be the more successful is quite another question. *Magna est veritas, praevalebit!*

Our satisfaction in the present physical outlook is further modified by two points. In the first place, we can not pretend to

give any explanation of electricity or of electrical energy in terms of anything more simple or fundamental, so that there is still no bottom found to the deep well of truth. In the second place, when we are confronted with questions as to the origin and the enduring qualities of things we have no physical suggestion whatever, not the vaguest guess, to offer in reply. Two of the most important movements of to-day are these. The insistence that science must confine its attention to observable and measurable quantities, thus sharply separating physics from speculative metaphysics; and secondly the growing possibility that the search for the ultimate nature of substance is futile and, like perpetual motion machines, may be safely abandoned. Effort is concentrated on the structure, on the form, arrangement and resulting habits or behaviour of things. Thus the appeal to models is passing away, and the trust in mathematical symbols, equations and deductions is growing stronger.

Personally I flatly rebel against all trammels and I advocate complete freedom in attacking all problems by any means available. When the key is lost, smash the lock and force the cupboard; and when the front stairs are blocked, try the back or a ladder outside. The work of many Anglo-Saxons has been of this direct and practical character, and it has proved singularly fruitful in face of difficulties. If Maxwell had been restrained, would his imaginative genius have produced his great treatise on electricity?

Age of the Universe

There is clearly stamped on the universe a great, but not an infinite antiquity. By all the known laws of physics the universe is a going concern, perhaps in middle age, which has not gone on forever and will not continue forever.

Two great tenets of science have been: (1) the conservation of mass, the foundation of chemistry, and (2) the conservation of energy, the foundation of physics. It now appears probable, from the physics of the stars, that matter can cease to exist as such and give birth to a precisely equivalent amount of radiant energy. There is diligent search for the reciprocal transformation, whereby the

continual outpourings of light and heat, radiating from all the stars and spreading into empty space, may again collect and reorganize into electrons, protons and atoms. No such changes are at present discernible.

Newton's queries in his "Optics" had some premonition of such energy changes:

> Are not gross Bodies and Light convertible into one another, and may not Bodies receive much of their Activity from the Particles of Light which enter into their composition?
>
> The changes of Bodies into Light and Light into Bodies is very conformable to the Course of Nature which seems delighted with Transmutation.

To-day this statement simply becomes, following Einstein,

$$E = Mc^2$$

where E is the energy, M is the mass and c the great constant, the velocity of light. By this equation we can express mass as energy, grams as ergs, or pounds as foot-pounds, or the converse.

It is not, however, the question of the annihilation of matter or the elimination of energy with which we are now concerned; rather it is the well-known fact that energy tends to become degraded or unavailable. All power machines and all life depend ultimately upon a source of heat relative to a cooler environment. Old age brings on that feebleness of energy which is no longer available when all has reached a dead level. There can not be water-power when the land is all at sea-level. Nor can you grind corn with water that has passed the mill! Unless indeed as now the beneficent rays of the sun, falling on the wide bosom of land and sea, lift again that water into the moving clouds to send a gracious rain on our inheritance. Many attempts have been made to remove this rather dismal picture of a worn-out universe from our imagination. Heat-death, it may be called.

The physical universe is proceeding, not to ruin, but to a dull uniformity. The energy will still be conserved, but it is becoming less and less available either for doing work or for sustaining life.

Had not Newton some conception of this question of the degradation of energy when he wrote the thirtieth query in his "Optics"? —"Motion is much more apt to be lost than to be got."

Jeans states that:

> Everything points with overwhelming force to a definite event, or series of events, of creation at some time or times, not infinitely remote. . . . . The universe can not have originated by chance out of its present ingredients, and neither can it always have been the same as now. For in either of these events no atoms would be left save such as are incapable of dissolving into radiation; there would be neither sunlight nor starlight, but only a cool glow of radiation uniformly diffused through space. This is, indeed, so far as present-day science can see, the final end towards which all creation moves, and at which it must at long last arrive.

Let us admit that "as far as present-day science can see" at the long last there are to remain some dead stars, some inert atoms and "the cool glow of radiation uniformly diffused through space," which must, of course, be perpetual, everlasting, devoid of change.

But does anybody seriously believe that?

Jeans himself admits that everything points with overwhelming force to a definite event, or series of events, of *creation* at some time or times, not infinitely remote. Where there is creation, then there is purpose. Where there has once been purpose, there may be continuation of purpose, or a recurrence of purpose. So also if there was once creation there may be a continuance of creation or a fresh creation. Eliminate purpose and there is no creation and no beginning to the physical universe. At what stage then can purpose be eliminated? This question is not now popular, and the word "teleology", meaning purpose, or direction towards an end in view, is largely taboo in science to-day. But why?

This tendency of energy towards decadence was never more exquisitely stated than in the "Tempest," when Prospero, after showing his vision, exclaims:

> These our actors,
> As I foretold you, were all spirits, and
> Are melted into air, into thin air:
> And, like the baseless fabric of this vision,
> The cloud-capp'd towers, the gorgeous palaces,
> The solemn temples, the great globe itself,
> Yea, all which it inherits, shall dissolve,
> And, like this insubstantial pageant faded,
> Leave not a rack behind. We are such stuff
> As dreams are made on; and our little life
> Is rounded with a sleep.

After which he begs us—

> Bear with my weakness; my old brain is troubled.

Well! Troy, Babylon, Carthage, have gone and we do not greatly lament them, and shall our turn not come? "Heraclitus is dead; and he was a better man than thou!"

Where we now are there was a sheet of ice perhaps four thousand feet thick. The ice will come again, and perchance go again, but ultimately it will remain.

And yet the full tide of pessimism has not been fathomed, for consider the words of Bertrand Russell in "Mysticism and Logic":

> That man is the product of causes which had no prevision of the end they were achieving; that his origin, his growth, his hopes and fears, his loves and his beliefs are but the outcome of accidental collocations of atoms; that no fire, no heroism, no intensity of thought and feeling can preserve an individual life beyond the grave; that all the labours of all the ages, all the devotion, all the inspiration, all the noonday brightness of human genius are destined to extinction in the vast death of the solar system, and that the whole temple of man's achievement must inevitably be buried beneath the debris of a universe in ruins—all these things, if not quite beyond dispute, are yet so nearly certain that no philosophy which rejects them can hope to stand.

Here indeed we have the very quintessence of ultra-pessimism. But as the man who tried to be a philosopher said to Dr. Johnson, "Cheerfulness will keep breaking through." Nobody need believe these things unless he likes; indeed we do not really know all this.

For another great philosopher, Whitehead, writes, "The fact of the religious vision and its history of persistent expansion is our one ground of optimism. Apart from it, human life is a flash of occasional enjoyment, lighting up a mass of pain and misery, a bagatelle of transient experience." But even this optimism has a decidedly neutral tint. The fact is that we are in a period of great flux and change, still under the shadow of the great war and its gloomy aftermath. It is the glory, the privilege and the responsibility of the present generations that they have immense new problems to solve. If we conform to the narrow limitations of a purely mechanical outlook, we shall never see the wood for the trees, and we shall reap as we sow. If the greater qualities are brought into

play, then there may be success! What are these qualities? Dean Inge has compactly described them—"truthfulness, courage, justice and fair play, abhorrence of meanness and crooked dealing, and respect for all human beings as such."

The tendencies that we observe in a long period of time are really ephemeral; a fly, living but for a day, can not hope to detect the motion of the planet Neptune. It was a fly, too, in the fable, that, seated on a chariot wheel, exclaimed, "See! what a dust do I stir!"

Perhaps we should never say that at some distant date the universe was created; rather let us say, the universe is now being created, and insist that at all times such a statement has been true. Shall we add with Walt Whitman that the universe was never more perfect than it is now, and conclude with Marcus Aurelius, "Could he say of Athens, Thou lovely city of Cecrops, and shalt thou not say of the world, Thou lovely city of God?"

Time

Like other entities time is a matter of experience. To the mathematician time is readily reversible, but in experience the past and the future are sharply distinguished. I can actually go to California and back, but not to last week and back, except in memory.

Yet if I go to California, I must expend time to cover space; nor is my journey direct, but to right or left, up and down, added to the actual distance, so that we have three degrees or types of space linked to one of time, and Minkowski brilliantly showed us how inevitably these were united in the four-fold union of space-time.

It has always seemed to me that even in this four-dimensional union something is still lacking. In order to go to California I must have money, an important fifth degree of freedom. It is well known, however, that money is merely the opportunity to acquire what we think we need, and on a journey money buys energy, so requisite for the traveler's life and movement, and no less essential to the army of workers who to-day assist him on his journey whether by direct or mechanical means. A bird can obtain its energy

directly from food, and requires no money for sustenance, clothes or transportation.

The fifth degree of freedom is, therefore, energy, and a large part of it we derive from breathing air, the only thing still free to all, without taxation or payment.

It is a remarkable fact that, in physics, energy has an intimate relation with time, and also with frequency; so that it is a particular fad of the author to endeavour to ascertain to what extent we can substitute the frequency of waves for the perhaps less tangible, but more familiar, concept of energy. This is scarcely the place to enlarge on this idea; and it must suffice to point out that, as Einstein explained gravitation on a geometrical basis, so it may be possible to consider energy more fully as an aspect of frequency, possibly arriving at a comprehensive wave theory of the universe.

Eddington in his "Nature of the Physical Universe" sets forth a fascinating picture of the inevitable unidirectional progress of time, as almost embedded in nature. The second law of thermodynamics, the running down of the universe as if it were a clock, with the gradual degradation and unavailability of energy, are picturesquely referred to as "time's arrow." The fact that certain processes in nature can not be reversed may lead to the result that time can not be reversed. To an intelligence higher than our own, time past, present and future might conceivably have a oneness quite foreign to our experience, but not perhaps beyond the imagination of a mathematician.

Life

So far we have considered matter apart from life. All the difficulties hitherto encountered become intensified by a new factor which can not even be defined, when we consider living things. To suggest that life is merely mechanism is to confuse two terms with quite different meanings. Machines are contrived from without, but living things are organized from within, and we can not definitely demonstrate either conscious purpose or intelligent directing mind. Yet we do see the most marvelous co-ordination of the whole, due to the co-operation of the constituent parts. I am speaking of

such things as trees and bees, and of many happenings within our own bodies. Were these events left to our conscious and intelligent selves, then our lives would not be prolonged for a minute. We have not intelligence enough to manage even a minute part of our bodies for a small fraction of a second. For example, who of us all would dare to assume complete responsibility for the output of new blood corpuscles, or for the necessary continual repairs, say, to his eye?

If a man breaks a leg, nature repairs it for him. Who and what is this nature?

> Nature is neither kernel nor husk—she is everything at once.
>
> —*Goethe*

> Nature is at once a *science* which never leaves off deducing effects from causes and an *art* which without end exercises itself in new inventions.
>
> —*Lachelier*

> Nature is now no more—even to the scientific thinker—a mechanical contrivance like a complicated and highly ingenious machine. . . . . Nature is—what it always has been to the common sense view—a texture in which the mechanical warp is shot through everywhere by the spiritual woof.
>
> —*Merz, modified from William Jones*

That living creatures are constructed of matter no one will for a moment dispute; that there are, in life, transferences of energy which fully obey the laws of physics and chemistry no one will deny, but to insist that these laws or theories, as we now know them or even as they may develop, impose a necessary limitation to our conception of life, or to regard them even remotely as causation, is a step quite unwarrantable. What then do we need to add? There is nothing to suggest! But because no answer is at present forthcoming we can not assume that an answer is forever impossible. No doubt one important factor is the organization as a whole, which is not merely a sum of its parts.

The pretty quarrel between mechanists and vitalists and neovitalists is likely to continue with varied success on shifting battlefields. We can hardly be expected to settle the question this evening.

Let us, however, note three conclusions: Every form of matter comes from matter; every form of energy comes from energy; every living cell comes from a living cell.

The first two statements have already been shown to blend into one, so that matter may now be regarded as merely one form of energy. Nor need we doubt that life is also a form or manifestation of energy. What, then, is energy? Every schoolboy is ready with the answer, "Energy is the capacity for doing work." A mere translation! However, many schoolboys are capable of the more important step of actually measuring such work. Yet the definition reminds us of the gibe of Ruskin. "Why are the leaves of a tree green?" "Because they contain chlorophyll." "Then," he says, "you tell me that leaves are green because they contain green-leaf!" But truly, the situation is not as bad as it seems, inasmuch as man has now acquired so full a knowledge of what we may term the "habits of energy" that he can not only trace the interchanges of energy in nature, but he can also direct energy to his advantage and benefit. There is the enormous further achievement that energy is measurable by man and this is the first necessity for control. Hence there arise the multitudinous applications of mechanics and electricity which have invaded our lives in abundance and with such complexity, all depending upon known principles of physics. Indeed, we are rather intoxicated by these successes which leave the impression of far greater wisdom than perhaps we can justly claim, and we are apt to regard progress in civilization, which, of course, depends not only on material, but on intellectual, moral and spiritual values and qualifications.

Origin of Life

As to the origin of life, it remains, like the origin of matter, quite obscure. But the problem is not in the same category. To account for the origin of matter we have to regard it as arising from nothing; we have to consider energy proceeding from no energy, something quite outside our experience, and so unthinkable. It is not so when we consider the origin of life, where the material and the energy are both available. Hence there is speculation in the direction of highly complex molecules originating, step by step, from the simpler available molecules by the action of ultra-violet rays of the sun. Some first fruits of chemical experiments in that

direction have appeared. To be precise, sunlight has coaxed, so to speak, water and carbon dioxide to form formaldehyde. That step is truly a long way from the living cell. Rather vague terms are used to explain the further stages, such as surface tension and osmotic pressure, but my biological friends state that no "simple" cell is known to them. There is very great complexity in the simplest forms of life. Moreover, an eminent physiologist (Adrian) has stated:

> The nervous system is a mass of living cells which has the extraordinary property of appearing to influence, and to be influenced by, the mind. . . . . It is a material system somehow responsible for such non-material things as emotions and thoughts. These are in a category outside the range of mechanical explanation, and for this reason the working of the nervous system will never be fully explainable in terms of physics and chemistry.

Again, Lord Balfour, writing as a philosopher, states, "No man can either perceive or imagine the mode in which physiological changes give birth to psychical experiences."

Most of us will concur with these verdicts, but we must remember that there is a more daring school who repudiate these limitations, due, they say, to the present imperfect state of our knowledge.

If the organic rose from the inorganic, then there is the first stage of the stupendous developments of life, both in number and in type, which surround us on this wonderful planet. Certainly a single flat of creation has, in most thinking minds, given way to the more glorious conception of the perpetual creation which surrounds us. To-day is created anew from yesterday. One second gives birth to a fresh and different succeeding second, and yet between them an enduring linkage occurs. While it is not difficult to coin phrases to describe and summarize this remarkable development, and perhaps the term creative evolution is the most helpful, yet we must use it merely as a label or description, and avoid the common blunder of confusing a name with a cause.

Somehow in the human frame the front legs have become arms, and the front feet, hands, while one digit on each hand has become a thumb. The young child crawling on all fours as a little quadruped painfully and with repeated practice raises himself on his hind legs and learns to walk. Only the anatomists and physiologists are

fully aware of the intricate coordinations which these efforts, conscious and unconscious, demand on the brain, nerve and muscle. Does the young child herein repeat a part of the story of the race, of its ancestry? Indeed, it has been stated that "every bone and every muscle of man's body have undergone profound structural alterations to fit him to his orthograd posture."

Certainly repeated struggles and strivings are necessary for the preservation and development of every form of life, while disuse leads towards annihilation; but these sage reflections, which may briefly summarize an observable process, leave all the most fundamental questions unanswered.

The highest development perceived or known in the universe is found in the intelligence and soul of man. Just as the properties of space have given rise to the rather vague term, ether, as a term indicative of properties and happenings, so such words as mind and soul are convenient summaries for unquestionable attributes.

It is somewhat strange to think that if the whole human species were submerged in Lake Ontario the water would rise but a few inches, and doubtless the universe as a whole would go forward but slightly affected, and dynamically and materially unimpaired. There was such a time, perhaps less than ten thousand million years ago, when there was no life on this earth; there will be such a time perhaps a hundred thousand million years hence when life on the earth will have passed away. Few will dispute the calculation of Harold Jeffreys that in a million million years all the waters of the ocean will have frozen to the very bottom and all the land covered with ice and snow. Go, however, into one of our great libraries and you will find the majority of books deal with man and his history and achievements. Why this importance attached to man? Do we flatter ourselves? Can we be just super-monkeys traveling on a speck of a planet going round a commonplace sun?

This pessimistic suggestion stands in sharp and dark contrast with the idea that this world is a training ground for immortal spirits. The view of Professor A. N. Whitehead may prevail that though the universe is physically descending, yet it is spiritually ascending.

Physical Fields

In order to further an attempt to approach a general view of the universe it is desirable to return for a while to the ideas of Faraday and to contemplate what he termed fields of force, or, as we might say, domains of energy. In a notable sentence he writes:

> The view now stated of the constitution of matter would seem to involve necessarily the conclusion that matter fills all space, or, at least, all space to which gravitation extends (including the sun and its system); for gravitation is a property of matter dependent on a certain force, and it is this force which constitues the matter. In that view, matter is not merely mutually penetrable, but each atom extends, so to say, throughout the whole of the solar system, yet always retaining its own centre of force.

It is probable that Einstein could modify this statement so as to cover his theory of gravitation where a geometrical field is caused or modified throughout space, so as to account for the motion of the heavenly bodies without the "forces" of which Newton conceived and about which Faraday was writing.

The word "field" has a wide use in the English language, such as hayfield, battlefield and so forth. In every case it denotes an area or region of events or happenings. Its introduction into physics has been fruitful. Near the earth, matter falls towards the earth in straight lines or curves and we can explore the laws or habits of material objects in this gravitational field. Newton extended this localized field from the earth outwards to the moon and throughout the solar system. To-day the field is extended to include the motion of the double stars.

Around the earth there is also a magnetic field wherein a compass needle takes a definite direction. So also an electrically charged body is surrounded by an electrical field. At the present time we are immersed in an electromagnetic field, witness these rays of light perceived by our eyes, and the radio or wireless waves which now at all times penetrate even through our homes and very bodies. Attention should be directed to the important fact that there may be complete overlapping of fields. At one and the same place gravitational, electric and magnetic fields co-exist. Hence the efforts of Einstein and of Eddington to get one, and only one, "field" which will give a full description of all gravitational and electromagnetic events.

Three things are essential for perception: the source or broadcasting station; the receiver, which must be duly tuned to the source, and the transfer of energy through space. Thus the atoms in the sun broadcast light to us, but we perceive with our eyes only those rays to which our eyes are tuned—that visible octave which is but a fraction of the great spectrum of total radiation.

The importance of correct tuning is now well understood in radio reception, as in all electromagnetic fields, but it is desirable to realize its wider applications. Conversation in the ordinary sense is not possible either by the dumb or to the deaf. The one lacks the transmitting power of speech, the other the receptive power of hearing. Now there are also mental or intellectual fields where a thinker has ideas which he wishes to convey by speech or writing to other intelligences who are willing to understand and recieve them. Who can overemphasize the importance not only of intellectual capacity, but also of sympathetic tuning in all mental fields, wherein again form, structure and style are nearly as important as subject or substance?

No less is this true in all forms of art. It is the glory of the artist to create an artistic field. Appreciation of this field by the observer or recipients again depends on the receptivity both as regards capacity, and quality or value. In mental and artistic fields all the precision of mathematical physics is lacking. Measurable quantities are entirely absent. Judgment, good sense and experience are the sole guides of value. But there is beyond all this, indefinable and precious, that inspiration and genius which persuade us that there is something more and something greater than we can include and define in purely physical fields. Yet if we are going to chop up the universe into wholly independent regions, we at once lose that simplicity and generality which it is our hope and ambition to achieve. It is believed that when conflict arises between two domains of thought, for example, religion and science, the reason for such conflict resides in our limited knowledge and intelligence. When conflicts occur in nature, readjustment necessarily and inevitably corrects them.

Greatest of all are those fields where the spirit of man is tuned

to the spirit of the universe, so that man is, as it were, a god, or is in complete communion with God.

Are these ideas idle dreams or fantastic visions? No! We can claim as much reality for spiritual fields as for mental, artistic or physical fields. "By their fruits ye shall know them!" Here indeed may be the secret of secrets! The direct evidence of spiritual fields is found in the attributes and experience of those who, finding themselves *en rapport* with the divine light, bear testimony, by their lives, by their actions, by their thoughts, by their influence, that the inner light guided by reason is no mere illusion or dream.

I choose two illustrations. Mr. Baldwin, politician and statesman, lately premier of England, states:

> For myself I say that if I did not feel that our work and the work of all others who hold the same faith and ideals, whether in politics or civic work, was done in the faith and the hope that some day, maybe a million years hence, the kingdom of God would spread over the whole world, then I would have no hope, I could do no more work and I would give my office over this morning to any one who would take it.

These words of Mr. Baldwin's evoke admiration and awake an echo in our souls. And yet—there is a stage even more noble, where those who feel that they are playing a losing game or know that they are fighting a hopeless battle persevere in their undaunted quest for the truth, which includes all that is good and beautiful, persevere in scorn of consequence.

Yet one more witness by a woman, who, in face of disappointments, ill health and approaching death, wrote that fine swan-song, "No coward soul am I!", concluding with her life's vision:

> With wide embracing love
> Thy Spirit animates eternal years
> Pervades and broods above
> Changes, sustains, dissolves, creates and rears
> Though earth and man were gone
> And suns and universes ceased to be
> And thou wert left alone
> Every existence would exist in Thee.
>
> —*The last poem of Emily Brontë*

McGill University,
Montreal.

ON THE PERIODS OF THE STARS OF THE MIRA-TYPE

By Rev. Fr. Lause

Everywhere in creation we observe a wonderful variety. This appears also in the variable stars. We may distinguish ten classes of them at least, all of them very interesting.

Nearly half of all these stars belongs to the class of the long period variables. In the following article we shall discuss the periods of these mysterious stars and their remarkable changes.

1. It is difficult to specify the exact point of division between long-period variables and stars of the δ Cephei type. The star l Carinae, with a period of 36 days, is doubtless a Cepheid and for some others with periods up to 64 days (CG Sagittarii) this is almost certain.[1] On the other hand T Centauri, with a period of 91 days shows the spectrum Me and other peculiarities of the long-period variables. RU Velorum with a period of 63 days has the spectrum M3e and is, therefore, likely to be a variable star of the Mira-type. With nearly 20 other stars, of which the periods are between 50 and 90 days, we do not yet know if they are Cepheids, Mira-stars or crosses of these two types. They show some peculiarities of both classes, but also differences from the two. As yet it is impossible to decide this question. On the other hand there are nearly a dozen stars with periods longer than 600 days. They are the following ones:

Star	Spectrum	Period	Star	Spectrum	Period
S Cassiopeiae	Se	613[d]	S Persei	M5	840?
R T Cephei	?	625	U Z Persei	M4	907
R W Cygni	M1	631	T W Pegasi	M6	934
S W Geminorum	M2	698	U W Aquilae	?	950
V X Sagittarii	M3e	731	V Hydrae	N	6200
U V Orionis	?	760			

S Cassiopeiae, RT Cephei and UX Sagittarii doubtless belong

[1]These and other details are taken from the *Handbuch der Astrophysik*, which is one of the books most necessary for the library of every observer of variable stars; it is written partly in German, partly in English.

to the Mira-type; but the other stars of the table are probably not real Mira-stars. WZ Persei, TW Pegasi and V Hydrae are likely to form a new class of variable stars (*Handbuch*, 867) for they have shorter periods of 90, 68[1] and 530 days, respectively, interfering with the longer ones. As for S Persei it seems to be more convenient to count it among the irregular variables.

It is interesting to investigate the frequencies of the periods. These are shown in the following table and in figure 1. The values were obtained from "Katalog und Ephemeriden veränderlicher Sterne für 1929," omitting the stars for which the periods are still uncertain and also the RV Tauri stars, because these probably form a special class.

Period (days)	No. of Stars	Period (days)	No. of Stars
50..... 99	30?	350.....399	123
100.....149	57	400.....449	68
150.....199	91	450.....499	25
200.....249	174	500.....549	10
250.....299	200	550.....599	7
300.....349	192	>600	3?

The periods of stars that at maximum are very faint seem to have a tendency to be shorter. For all variables with known periods Cannon and Campbell found a mean period of 284 days, while according to Miss H. Swope, the mean period of 57 faint variables in the Milky Way field 185, is 217 days. (*Handbuch*, 867.) We do not yet know if this is a common property of all fainter variables.

2. It is a peculiarity of the long-period variable stars, that generally their variability is not very regular. The brightness at minimum and especially at maximum, the form of the light curve and the periods are slightly and sometimes even considerably variable. This may be illustrated by two examples. The values for V Canum Venaticorum were secured by the author; the mean period is 186.1 days. The times of maxima and minima of X Ophiuchi were determined by Lacchini (*A.N.* 5650); the mean period of this star is 336.6 days.

[1]This period was found by the author from 134 observations, 1927-1929, *A.N.* 5645.

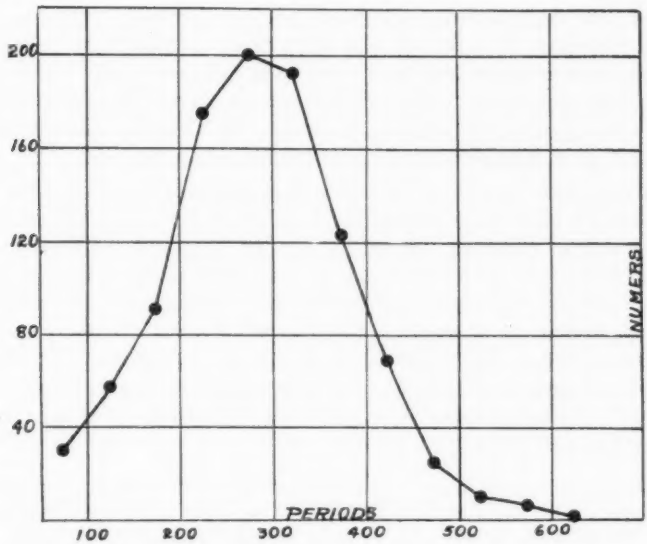


Figure 1.—Distribution of periods.

V Canum Venaticorum[1]

Maximum	Date J.D.	Interval	Minimum	Date J.D.	Interval
6.38^m	2425298	...	8.36^m	2425241	...
6.64	478	180^d	8.19	434	193^d
6.55	676	198	7.78	597	163
6.76	870	194	8.21	803	206

X Ophuichi

Maxima	Date J.D.	Interval	Minimum	Date J.D.	Interval
6.3	2422465	...	8.9	2422636	...
6.6	818	353^d	8.7	985	349^d
6.7	23146	328	8.7	23325	340
6.7	480	334	8.7	665	340
6.5	24166	686/2	8.6	992	327
6.6	487	321	8.6	24317	325
6.4	836	349	8.6	638	321

When a long period variable is observed for many years other peculiarities of the periods are often noticed. In many cases they

[1] The exact date of the minimum is difficult to fix.

are slowly, but continuously decreasing or increasing. The most remarkable star in this respect is R Hydrae. In the 18th century its period was about 500 days. In 1848 the period was 453 days and in 1914, 403 days. After the latter year the period was constant and then apparently began to increase. In "*Katalog und Ephemeriden*," R. Prager gives a period of 413.6 days for this star.

In a similar way the period of R Aquilae shortened. In 1856 it was 347 days, 10 years ago 310 days, and since that time, the period has remained constant (309.65 days). In opposition to these two stars there are many others which seem to show periodic oscillations. An example—R Aurigae may prove this.[1] It was said above that the single maxima or minima of a long-period variable mostly occur a little earlier or later than the constant period requires. Therefore from several observed maxima so-called normal maxima are formed. In this manner the normal maxima of the following table were obtained.

R AURIGAE

Normal Max.	Epoch	O-C_1	Normal Max.	Epoch	O-C_1
2401916	1	-48^d	2413860	27	$+32^d$
3311	4	−22	5228	30	+31
5143	8	−15	6575	33	+9
8380	15	+27	7917	36	−18
11136	21	+46	9246	39	−58
2503	24	+44			

In this table the Epoch designates the number of periods (456.3 days) that elapsed after an early maximum and O-C_1 the difference between the observed maximum and the calculated one of the latter computed by the formula

$$M = J.\ D.\ 2401508 + 456.3\ E.$$

The differences O-C_1 are considerable and seem to change periodically. When plotted graphically they closely cling to a sine curve, figure 2.

So for many years the maxima of R Aurigae were calculated by the formula

[1]Compare *Vierteljahrsschrift der Astronomischen Gesellschaft 1929, p. 50.*

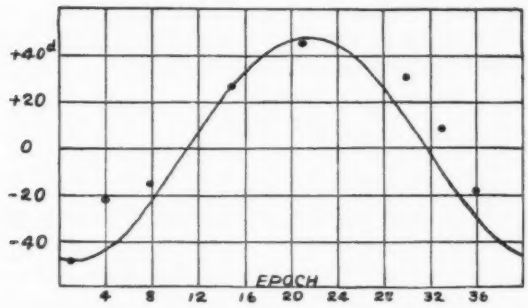


Figure 2.—Foundation of a sine term.

$$M = J.\ D.\ 2401510 + 456.3\ E + 48^{d} \sin\ (8°8.E + 261°)$$

Here 48 days is the greatest average divergence and $8°.8 = \frac{360.}{N}$ where N is the number of periods that are necessary for the whole sinoidal curve to be run through and 261° is the phase for that maximum in which E had the value zero.

Using this formula we obtain the following table:

R AURIGAE

Epoch	O–C₂	Epoch	O–C₂
1	−2d	27	−2
4	+19	30	+17
8	+6	33	+17
15	−1	36	+10
21	−4	39	−16
24	−3		

Except in the last years, the differences between observed and calculated maxima are slight. In older books and catalogues formulae of this kind are given for many long-period variable stars. It cannot be denied that they represent most of the observed maxima well, but the maxima calculated in advance by them often show great divergences. Therefore they are likely to have no real foundation in the star.

In recent years another method of computing the maxima of variable stars has been found. The periods of long-period variables

seem to have the peculiarity of turning shorter or longer from time to time. This change is often connected with a *jump* in the epoch. This may be illustrated again by R Aurigae.

R AURIGAE

Epoch	$O-C_3$	Epoch	$O-C_3$
1	-9^d	27	-13^d
4	+5	30	+9
8	−4	33	+10
15	+10	36	+6
21	+5	39	−11
24	−9		

Here till the epoch 24 the maxima were obtained by the formula

$$M = J.\ D.\ 2401465 + 460.3\ E$$

and the later ones by the formula

$$M = J.\ D.\ 2401758 + 448.7\ E.$$

The differences $O\text{-}C_3$ are less than before.

The possibility of such alterations in the period is confirmed by the strange behaviour of V Coronae Borealis and a few other stars. The period of this star was 355.9 days from 1878 to 1897 and from 1904 to the present time. Between 1897 and 1904 nobody has observed this star and in this very time the epoch must have changed + 61 days. It is not known whether this alteration happened suddenly or gradually.

It is impossible to explain why the periods of the long-period variable stars are not constant and why they change in such a strange manner. We still wait for a theory accounting for all peculiarities of these mysterious red giants. We must continue observing and studying them in every possible way and here the observations of the amateur may be of great scientific value if made carefully and assidously.

Heidelberg University.

THE WOLF-RAYET STARS

With Plate IX.

By C. S. Beals

The Wolf-Rayet stars, which were discovered by Wolf and Rayet at the Paris Observatory in 1867, constitute a class of bodies perhaps more interesting than any other in the sky, not only on account of the remarkable character of their spectra, but also because of the mystery which has long surrounded their physical nature. The distribution of these objects has been discussed by Campbell and by Plaskett, who have shown that they are highly concentrated to the plane of the galaxy and appear to be associated with absorption O-type stars. From this it is probably safe to assume that they are similar to the absorption O's in being very distant and highly luminous objects. Estimates of absolute magnitude made by Plaskett and by Gerasimovic, suggest that they are somewhat fainter than the absorption O's and an absolute magnitude of approximately –3.0 may, therefore, be tentatively assigned to them. The distinguishing characteristic of the Wolf-Rayet stars which differentiates them sharply from absorption line stars of the same spectral class, is the appearance in their spectra of atomic emission in the form of broad bands in place of the absorption lines which are found in the majority of stellar spectra. The wave lengths of many of these broad bands are identical with the wave lengths of absorption lines in ordinary O-type stars, and they are undoubtedly due to similar atoms. The emission wave lengths are often from 50 to 100 angstroms in width. Hence the term "band", which refers to their width rather than to their origin, has nothing to do with molecular spectra.

The nature of the physical conditions responsible for the unusual emission of Wolf-Rayet stars has long been a matter for speculation, and during the past few years extensive new observations of these objects have been made at a number of observatories. As a result of these investigations, a theory of Wolf-Rayet emission

has been put forward independently by Menzel[1] and by the present writer,[2] which appears satisfactorily to account for many of the peculiar properties of Wolf-Rayet spectra. According to this theory, (which was originally suggested by the obvious analogies between Wolf-Rayet spectra and the band spectra of Novae), conditions on the surface of a Wolf-Rayet star are such that gaseous material is continually being ejected in a radial direction and with high velocity into space. Such a star is thus surrounded by extensive nebulosity consisting of outward moving atoms, and it is in this nebulosity that Wolf-Rayet bands are considered to have their origin.

The mechanism of emission is probably similar to that believed to be responsible for the emission spectra of planetary nebulae. Ultra-violet light from the star is absorbed by the surrounding nebulous material and is re-emitted in the form of Wolf-Rayet bands in the ordinary region of observation. The great width of the emission bands is a natural consequence of the high velocities of the atoms ejected from the star. The extension in space of the ejected material may be assumed to be large, relative to the diameter of the central star, and the amount of the luminosity on the side of the star opposite to the observer, which is occulted by the star, will be relatively inappreciable. The gases on the side of the star nearer to the observer will, owing to their velocity, absorb in a wave-length to the violet of the normal position of an emission line, and they will, as a consequence, be transparent to emission from gases on the opposite side of the star which are moving in the opposite direction or at right angles with the line of sight. The observed intensity of an emission band will, therefore, be due to luminosity from gases moving both toward and away from the observer, and at right angles to the line of sight. Those atoms moving toward the observer will cause an extension of the band to the violet, while atoms moving in the opposite direction will cause a similar extension to the red. The filling in of the band between the two extremes may be attributed to the spread in velocities and to the fact that the velocities of emitting atoms make angles with the line of sight having all values from 0 to 180°.

[1] *Pub.A.S.P.*, Vol. 41, p. 344; [2] *M.N.R.A.S.*, Vol. XC, p. 202

The observational evidence on which this theory rests is, to a considerable extent, of a qualitative nature, though a quantitative check of considerable importance is provided by the measurement of band widths. If, as has been suggested, the broadness of the bands is due to the velocities of emitting atoms, then the measured widths of bands due to a given atom should increase linearly in passing from the violet to the red region of the spectrum in accordance with a theory of Doppler broadening. This has been shown to be the case for a number of the brighter stars in which the bands have been accurately measured. Another possible quantitative test is provided by measures of the contours of emission bands. The theoretical form of a band contour may be calculated if certain assumptions are made concerning the frequency curve of the velocities of ejected atoms. If it be assumed that the majority of velocities occur within a narrow range, then the calculation becomes quite simple, and photometric measurements made on the basis of this assumption show a reasonable correlation between the measured and predicted contours of the bands. This aspect of the question has not been exhaustively studied and offers a fruitful field for further research.

One of the most interesting of the phenomena connected with Wolf-Rayet spectra is the appearance of absorption borders on the violet edges of bands. All bands do not show the effect to the same degree, but the fact that many of them show strong absorption lines on their violet edge is a powerful argument in favour of the theory that Wolf-Rayet emission is a result of the continuous ejection of high speed atoms from the star. The explanation in terms of the theory is simple. The dark borders represent absorption of the continuous spectrum of the star by outward-moving atoms. Those atoms which are in a direct line between the star and the observer have the largest velocity of approach, hence the position of an absorption line would be expected to coincide with the violet edge of an emission band. The possibility of such an absorption line being observed would appear to depend partly on the frequency distribution of the velocities of absorbing atoms. If the spread in these velocities is relatively small, then it would appear logical to expect a reasonably well defined absorption line on the violet edge

of an emission band. If, on the other hand, the spread is large so that the frequency curve of velocities has a broad maximum, comparable in width with that of the emission band, then a definite line would not be expected, but the absorption would show itself rather in an alteration in the contour of the violet wing of the band.

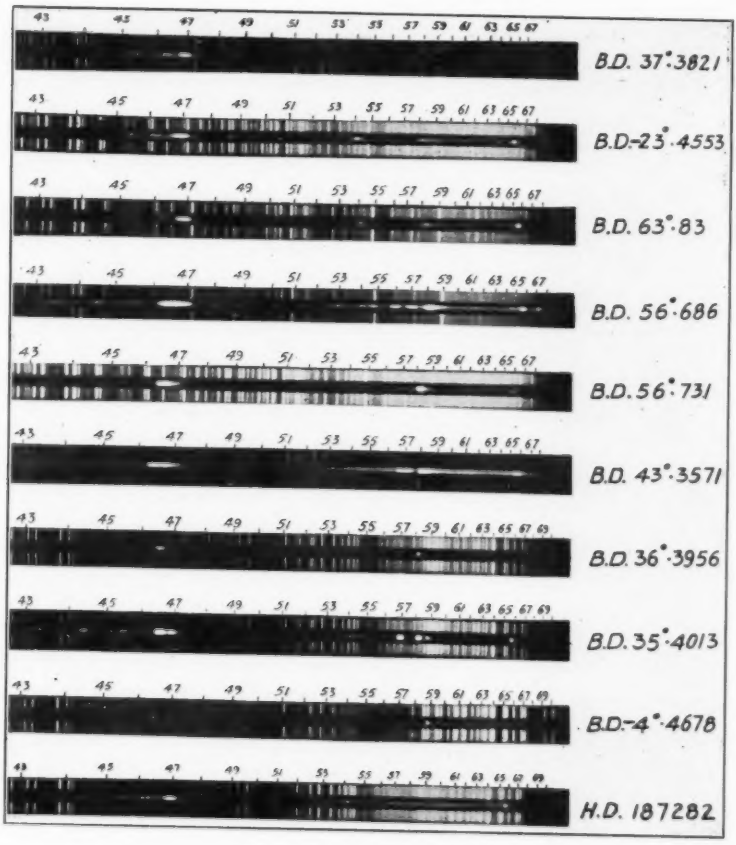
An observation which has occasioned some difficulty and which has called forth criticism of the present theory of Wolf-Rayet emission[3] is the appearance of absorption lines in the centres of some of the bands. This central absorption appears to be confined to very weak bands which show small contrast with the continuous spectrum. A reasonable explanation of this phenomenon is that the undisplaced absorption lines occur in the spectrum of the central star and that the emission, due to the nebulosity, is not sufficiently strong to completely obscure them. Since none of the stronger bands examined by the writer show signs of central absorption, this interpretation is very probably the correct one.

The theory that emission of Wolf-Rayet type is due to the continuous ejection of gaseous material from stars may also be applied to explain the well-known P Cygni type of spectrum which consists of moderately narrow emission lines bordered by absorption on their violet edges. An examination of the spectrum of P Cygni itself, the brightest object of this class, shows that not only are the dark borders of the emission lines a prominent feature, but that the width of emission lines increases on passing to the longer wave lengths in a manner similar to that shown by Wolf-Rayet bands. The widths of P Cygni lines are small, of the order of 3 or 4 angstroms, and these objects are of considerably later type than the Wolf-Rayet stars. Nevertheless, the logical explanation which the ejection theory gives of the varying width of emission lines, and the appearance of absorption borders, strongly supports the idea that a similar physical cause is responsible for the emission in the two cases.

The theory of Wolf-Rayet emission outlined in this article was developed independently of any assumption concerning the nature of the forces responsible for the ejection of atoms from the star. It seems probable, however, that the cause of the phenomenon is to

[3] *H.B.* 874, pages, 25-26.

PLATE IX



TYPICAL WOLF-RAYET SPECTRA

be found in the action of selective radiation pressure, since there seems to be available no other agency capable of producing the observed effects. The idea that high speed atoms may be ejected from stars by radiation pressure receives confirmation from the theoretical work of Milne[4] and Johnson[5], and it is possible on the basis of their calculations to account not only for the observed velocities, but also the peculiar relative intensities shown by Wolf-Rayet bands as compared with wave lengths in absorption line stars due to similar atoms. The ejection of atoms from a star by selective radiation pressure is favoured both by high photospheric temperatures and by low values of surface gravity. It seems probable, therefore, that the relation of Wolf-Rayet stars to absorption line stars of early type and to the P Cygni stars will ultimately be explained in terms of the relative variations of one or both of these particular physical properties.

Dominion Astrophysical Observatory,
Victoria, B.C.

[4]*M.N.R.A.S., Vol.* 86, 459, 1926. [5]*M.N.R.A.S., Vol.* 86, 300, 1926.

largest of the asteroids, Ceres, (diameter 480 miles) if removed to the same distance. Finally the orbit is no sufficient ground upon which to venture a decision as to the nature of such an object. Here is suggested an obvious analogy between the Sun's increased family of planets and the satellite system of Jupiter whose newer satellites have orbits at considerable variance with these of the older satellites, just as the orbit of Planet X differs from those of its older brotthers. It is pertinent to draw attention to the fact that Planet X has, like the older planets, direct motion about the Sun.

This then appears to be a Trans-Neptunian, non-cometary, non-asteroidal body that fits substantially Lowell's predicted longitude, inclination and distance for his Planet X. Lowell considered his predicted data as only approximate, and a one to one correspondence between forecast and find would not be expected by those familiar with the problem. As he himself said in his Trans-Neptunian Plant Memoir: "Analytics thought to promise the precision of a rifle and finds it must rely upon the promiscuity of a shot gun." This remarkable Trans-Neptunian planetary body has been found as a direct result of Lowell's work, planning and convictions, and there appears present justification for referring to it as his Planet X.

It seems time now that this body should be given a name of its own. Many names have been suggested and among them Minerva and Pluto have been very popular. But, as Minerva has long been used for one of the asteroids it is really not available for this object. However, Pluto seems very appropriate and we are proposing to the American Astronomical Society and to the Royal Astronomical Society, that this name be given it. As far as we know Pluto was first suggested by Miss Venetia Burney, aged 11, of Oxford, England.† As a fitting symbol to go with the name we have suggested **PL**, easily remembered because the first two letters of the name and not to be confused with the symbols of the other planets.

V. M. SLIPHER.

Flagstaff, Arizona,
May 1, 1930.

†Kindly cabled by Prof. H. H. Turner.

(The reproduction of the symbol suggested is very rough.—*Editor*)

REVIEW OF PUBLICATIONS

L'Ancienne et la Nouvelle Théorie des Quanta, par Eugène Bloch. 417 pages, 6½ × 10 in. Paris: Hermann, 1930. Price, 90 francs.

This book comprises two courses of lectures on the quantum theory given at the Sorbonne during the Sessions 1926-27 and 1928-29. The first half is devoted to tracing the development of the "old" quantum theory from the time the idea of discrete energy values was first introduced by Planck to explain the energy-distribution curve in black body radiation. Side by side with each advance in the theoretical field is set down its practical significance, together with the experiments used to test the predictions made; and the extent to which the results of the experiments agreed or did not agree with these predictions is discussed. Thus both the successes and the failures of the old theory are clearly exposed. Accordingly, this section of the book forms an excellent critical review of this part of physical theory, but I should not recommend it to anyone making a study of the quantum theory for the first time since, in order to cover a wide subject in comparatively little space, the author has been compelled to condense his subject matter and the beginner would do well to proceed more slowly. It does, however, to my mind, admirably fulfil its purpose of introducing the second part of the book, which is taken up with a consideration of de Broglie waves, the Schroedinger wave mechanics, and the matrix mechanics. The way in which each of these arose is described, together with the profound change in our views of the atom, and the electron, which they rendered necessary. The mathematical methods of both the wave mechanics and the matrix mechanics are given very fully, and the fundamental equivalence of the two theories is demonstrated. Applying these methods in simple cases, the author indicates clearly which of the problems solved with the new theory were solved equally well with the old, and which of them previously defied solutions. In the last two

chapters the Heisenberg principle of indeterminism, and the new statistical mechanics, are dealt with in a particularly satisfactory manner.

Thus the reader is led to see, in the first part of the book, not only why the idea of quanta, although contradictory to all former ideas, gained such support, but also why about 1924 the concepts of the theory as then accepted were felt to be inadequate; and in the second part he is shown how these concepts were revised in two separate, although equivalent, ways, and is given an idea of the extent to which the revision overcame the weaknesses of the old theory. It would seem, therefore, that the author has succeeded in producing a book which will be of great value to any student of the old quantum theory who wishes to proceed to a study of the new.

ELIZABETH ALLIN

Astronomy: an Introduction, by Robert H. Baker, Professor of Astronomy in the University of Illinois. 540 pages, 6 × 9 in. N.Y.: Van Nostrand, 1930. Price $3.75.

This is the latest of the flood of text-books on astronomy which have appeared in the last few years, and it is certainly one of the best. One sees at once that it is a thoroughly new production. It is evident that the author is a practical astronomer, a good teacher and a person exceptionally well informed on present-day researches.

The language is clear, direct and full of life. The diagrams are newly drawn and express well the author's ideas. Many of the photographs have never been seen in a book, while some which are not so new are improved by little additions. One might say that the book is "up to the minute", as it contains photographs of the Chicago planetarium and Planet X, and also a map of part of the path of the 1932 eclipse, drawn from unpublished data supplied by the American Ephemeris office.

There are twelve chapters. The first gives an introduction to the celestial sphere and starts the beginner observing. The next six chapters deal with the solar system; and the last five, being two-thirds of the book, give an excellent account of what has been learned in the last twenty years about the starry universe. One is impressed with the references to recent researches, and in every case the information given is precise—not just a general statement.

C. A. CHANT

NEWS AND COMMENTS

Mr. W. E. Harper and Dr. C. S. Beals of the Dominion Astrophysical Observatory, Victoria, will attend the meetings of the Astronomical Society of the Pacific, to be held in conjunction with the annual meeting of the Pacific Division of the American Association for the Advancement of Science at the University of Oregon, Eugene, Oregon, on June 18-21. Mr. Harper is Chairman of the programme committee, with Dr. Alfred H. Joy, Mount Wilson Observatory, and Dr. Robert J. Trumpler, Lick Observatory, as the other members. The Society will hold a joint session with the American Physical Society on Thursday afternoon, June 19.

The announcement of the Forty-Fourth Meeting of the American Astronomical Society, to be held at the Adler Planetarium and Astronomical Museum, Chicago, Illinois, September 3 to 5, 1930, has just been issued by the Secretary, Dr. Raymond S. Dugan, Princeton University Observatory, Princeton, N.J. This meeting will afford members a splendid opportunity of inspecting the new planetarium, which is under the directorship of Professor Philip Fox. Qualified members of the R.A.S.C. may be interested in becoming members of this sister society. The fees are two dollars yearly, or a life-membership fee varying from about thirty-nine dollars at the age of 20 to twelve and a half dollars at the age of 75. Applicatitons are to be signed by two or more members. Secretary Dugan would welcome informatiton relevant to the Appointment Service of the society for astronomical positions—at present there is a lengthy list of applicants and a short list of vacancies.

Dr. R. G. Aitken, who has been in charge of the active administration of Lick Observatory since July 1, 1923, with the title of associate director, has been named director, the appointment to date from July 1. (*Science*).

The executive committee of the American Association for the

Advancement of Science has announced that its summer meeting in 1931 shall be held at Pasadena, probably the third week in June, the hosts being the California Institute of Technology, the Mount Wilson Observatory and the Huntington Library, and the following winter meeting shall be held in New Orleans from December 28, 1931, to January 2, 1932. To fill the vacancy in the committee of Section D (Astronomy), caused by the death of Dr. Ralph H. Curtiss, the executive committee elected Dr. H. T. Stetson, of Perkins Observatory, Delaware, Ohio, to be a member of the section committee.

Comet a, 1930.—"The first comet to be discovered in 1930 goes to the credit of L. C. Peltier, an amateur astronomer at Delphos, Ohio, on February 19. The comet was also found on a photographic plate secured by Schwassmann and Wachmann at Bergedorf on the night of February 18. The two discoveries were quite independent, the announcement of Peltier's discovery reaching the European Central Station at Copenhagen, Denmark, only two hours before the message from Bergedorf".—(*Publications of the Astronomical Society of the Pacific.*)

REDeL.

NOTES AND QUERIES

Communications are invited, especially from amateurs. The Editor will try to secure answers to queries.

Open Tube Construction for Telescopes

In the *Journal of the British Astronomical Association*, Rev. T. E. R. Phillips and F. J. Hargreaves, two English astronomers, give some interesting information regarding open tubes, such as are used in all the large modern reflectors, and closed tubes, as are found in practically all refractors. They say:—

> There is a widely held view that reflectors are much inferior to refractors in defining power, assuming equal optical quality, and there can be little doubt that in most cases this is so, especially when the reflector tube is of metal and closed on all sides. Experience over a long priod at Headley (where is Mr. Phillips's observatory) with an 8-inch refractor and a 12¼-inch reflector in an iron tube shows that the number of nights when the image in the reflector is as good as that in the refractor is very small.

A third instrument at Headley, the Association's 18-inch reflector, formerly the property of the late N. E. Green, has recently been remounted in the dome formerly occupied by the 12¼-inch, and its performance since remounting is worthy of record in so far as it affects the question of the relative merits of the two types of instrument.

Before the remounting, the 18-inch mirror was carried in a square wooden tube, completely closed on all sides, and the image usually had the well-known reflector characteristics—unsteadiness, lack of crispness, and inability to bear high magnification.

The sides of this wooden tube were made after the manner of a door, with stiles, rails, and panels. The panels having for the most part rotted, they were removed prior to the remounting of the instrument, and it was decided not to close in at once the large openings left by their removal, in order to observe the effect of allowing their air to circulate freely through the tube. In brief, the effect is to remove the characteristic defects of the reflector, as far as primary images are concerned.

The performance of this instrument has surpassed all expectations—so much so that in spite of the great disparity of aperture it is now rare to find, on occasions of poor seeing, that the refractor image is steadier or better defined than that of the reflector.

Calendar Reform

There is a growing impression that the only reform of the calendar worth introducing is the 13-month year. Mr. George Eastman, of Rochester, N.Y., is chairman of a committee actively supporting this proposal and the literature issued by this committee gives many reasons for the change. Another very useful publication is "Thirteen-Month Calendar," by Julia E. Johnsen (N.Y., H. W. Wilson, 90c.). It gives reprints of articles both in favour of and against such a calendar, together with much other interesting matter on the subject. From two of the articles in this book I quote some historical statements.

1. *Why the Year Begins on January 1*

The reason that the year begins on January 1 is a "pretty reason," as Lear's poor fool would say. Julius Caesar, when he reformed the calendar in the year 46 B.C., evidently had in mind to begin the year with the shortest day. The winter solstice at Rome occured in that year on the twenty-fourth of December of the Julian calendar; consequently, the first day of the year would have fallen on December 25. But he delayed it seven days out of regard for prevailing customs and the superstitions of the people. As they had been accustomed to a lunar calendar, they would be better satisfied if the first year of the new calendar came in with the new moon. Accordingly the mean new moon was carefully computed and the new calendar had its beginning on the first of January, 45 B.C.

at sixteen minutes past six in the afternoon.—Charles D. Stewart in *Atlantic Monthly*, January, 1926.)

2. *Interesting Calendar Events*

45 B.C.—Julius Cæsar put the Julian calendar into effect in Rome. The name of the month Quintilis was changed to July in honour of Julius Cæsar.

8 B.C.—Augustus Cæsar persuaded the Roman Senate to change the name of the month Sextilis to August, in his own honour.

532 A.D.—The Christian Era was invented by a monk, Dionysius Exiguus. It is held to have begun on January 1, in the middle of the 4th year of the 194th Olympiad; the 753rd year of the building of Rome and 4714 of the Julian Period. The Christian Era was introduced in Italy some time in the 6th century.

816 A.D.—The Christian Era was ordered to be used by Bishops of the Council of Chelsea, but was not generally used until several centuries later.

879 A.D.—King Charles III of Germany was the first to add "In the year of Our Lord" to the date of his reign.

1582 A.D.—The new calendar, known as the Gregorian calendar, was put into effect in four countries—Italy, Spain, Portugal and France.

1583 A.D.—Switzerland and the Catholic Netherlands adopted the Gregorian calendar.

1609 A.D.—The Protestant states of Germany adopted the Gregorian calendar.

1751 A.D.—The Calendar New Style Act was passed by the British Parliament. It was introduced by Lord Chesterfield.

1752 A.D.—The Calendar New Style Act came into effect, resulting in the adoption of the Gregorian calendar by Great Britain and all her colonies, including the American colonies. Prior to this the 25th of March had been the beginning of New Year in Great Britain.

1873—Gregorian calendar adopted by Japan.

1912—Gregorian calendar adopted by Chinese Republic.

1917—Gregorian calendar adopted by the Turkish Parliament.

1918—Bolshevist government of Russia adopted the Gregorian calendar.

1923—Greece and the Greek Church adopted the Gregorian calendar.

1923—The League of Nations appointed a Committee of Inquiry on Calendar Simplification. This committee analyzed 185 proposals from 38 nations and filed a comprehensive report to the League.

1928—On July 9 the National Committee on Calendar Simplification was organized at Washington, D.C. Although not an official organization it had representatives from the Federal departments of the Treasury, Navy, Interior, Agriculture, Commerce, Labour, Interstate Commerce Commission, as well as from industrial, business and civil interests.—(*Congressional Digest*, April, 1929, with additions).

An Astronomer Draws the Line

In pursuing his calling the astronomer has many and varied experiences, some of which demand endurance and resourcefulness.

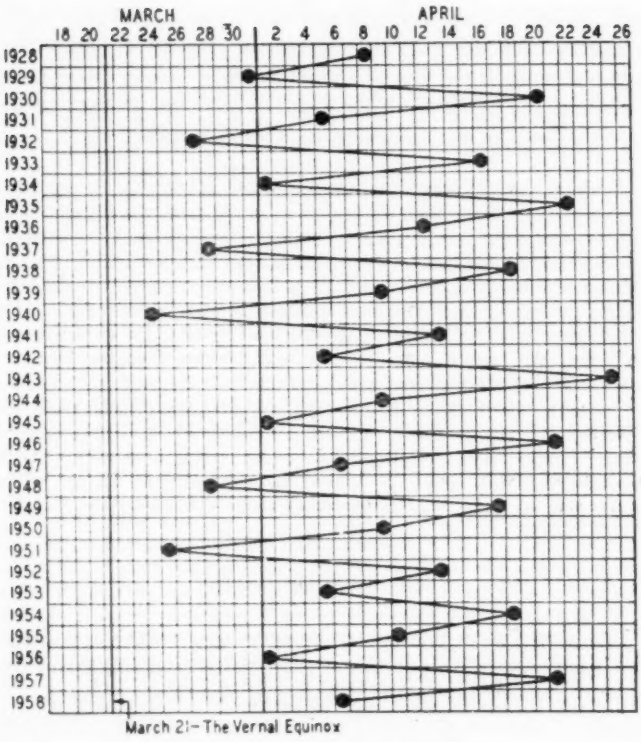
Dr. C. G. Abbot in "The Sun and the Welfare of Man", which is volume two of the notable Smithsonian Scientific Series now in course of publication, gives some incidents in his persistent attempts to measure the radiation of the sun. In one case, at least, he had to draw the line, as the following paragraph shows:—

> Once in a while something funny happens all by itself. In the early days at Harqua Hala, the writer shot a skunk that was wandering about the premises. Mr. F. A. Greeley, who knew how, skinned the animal. Its flesh looked so attractitve that the writer proposed cooking it. So we cleaned it with extreme care, avoiding entirely any disagreeable odour. The proper dish seemed to be a stew, which was prepared with potatoes and seasoning, as if made of rabbit or chicken. During the evening, the stew was cooked slowly over the reading lamp for hours, and warmed up on the next day for dinner. I helped Mr. Greeley to a nice piece of the meat, with a generous dish of gravy and potato. As he tasted the first mouthful I asked him if he liked it. I am not likely to forget the expression of his face as he replied, "I can't really say that I do". After trying a mouthful myself, I entirely agreed with him. We threw the remainder as far as we could over the edge of a cliff for less squeamish animals than ourselves to feast on.

The Date of Easter

This year Easter Sunday came very late, namely, on April 20. It is briefly stated as the first Sunday after the full moon which happens upon, or next after, the day of the vernal equinox. This time was chosen in order to give Easter pilgrims the advantage of being able to travel by moonlight on their journeys. But the above simple method of determining the date is not satisfactory and empirical rules have been devised for the purpose. The proposal to stabilize the date of Easter is not an essential part of calendar reform but it is recognized as very desirable from both ecclesiastical and economic points of view.

The accompanying diagram, taken from one of the publications of the U.S. National Committee of Calendar Simplification, illustrates the vagaries of the present method of determining Easter. There is a widely expressed wish that it be fixed somewhere near the middle of April, and the various church authorities state that there is no objection from the point of view of dogma.



THE DATE OF EASTER, 1928-1958.
as determined from the Moon's phases and the Equinox.

AN AGRICULTURAL OBSERVATION

Seen on a sign on the way to the annual Convocation at the Ontario Agricultural College:—

"Eggs fresh laid in cartons."

C.A.C.

MEETINGS OF THE SOCIETY

AT OTTAWA

Soirée at the Dominion Observatory

On Friday, May 2nd, 1930, the members of the Ottawa Centre and their friends, were invited to a soirée at the Dominion Observatory.

Due to the courtesy of the Director, Mr. Meldrum Stewart and his staff, all departments of the observatory were open to the guests and the various instruments were demonstrated. After the guests had inspected the different exhibits, refreshments were served.

Beginning in the basement of the building, then going to the first and second floors, and lastly to the dome, the following divisions were inspected.

In the Seismological division, a small working model of a horizontal seismograph was used to demonstrate how the instrument responds to earth movements, and also the method of photographically recording these movements.

The Ottawa records of the Grand Banks earthquake of November 18, 1929, were on display, together with a map on which was indicated the geographical position of the several seismological stations at which this tremor was recorded. A correlation chart showing the seismogram interpretation at each of these stations demonstrated the accuracy with which distances and time of occurrence can be computed. Another chart showed the method of determining the epicentre from the data collected from the stations listed.

A number of special seismograms such as the records of the Quebec earthquake of February 28, 1925, the Tokyo earthquake of September 1, 1923, the Pacific earthquake of February 3, 1923, the last named being the most severe of those yet recorded at this station.

In the Solar Physics department various instruments and their uses were explained to the visitors. Much interest was shown in the 80-foot coelostat telescope, the 23-foot solar spectrograph and the solar camera. Through a direct vision spectroscope, the lines produced by various metal salts in a Bunsen flame were examined.

On exhibition in another room were photographs of solar and comparison spectra, sunspots, a transit of Mercury and also a series of photographs of the partial eclipse, visible at Ottawa on April 28 of this year. Charts of sunspots variation in relation to rainfall, tree growth, the number of hares, grasshoppers and grouse, were also shown. In this room also, solar spectra were examined through the large Toepfer measuring engine and the Ottawa double spectrocomparator.

A Foucault pendulum, about 30 feet long, set up in the main hallway, attracted much attention. This experiment was under the Gravity division.

Gravity instruments shown included two vertical magnetic field balances, a Mendenhall Pendulum apparatus, and three types of torsion balances used for refined measurements of gravity.

Keen interest was shown in the Library of the Observatory. Here are housed 16,000 books on astronomy and allied subjects, and also many hundred publications and a large number of astronomical lantern slides.

The method of determining time from the transits of stars was very fascinating to many of the visitors. The uses of the small portable transit instruments and the meridian circle with their travelling wire micrometers, which record the time of transit on the printing chronograph situated in an adjoining room, were fully explained and elicited many interesting remarks. The master clocks in the Time Room and their method of synchronization with the primary clocks in the underground clock vault, were shown, and also how they control the time systems in the various government buildings in different parts of the city. A series of slides illustrating the methods of time-keeping from the age of the sun-dial to the present Synchronome clock was shown and the skilful and artistic work of the clock makers of the early days was a revelation to many. In the Wireless Room the distribution and the reception of time signals was illustrated and an interesting experiment showing the control of clocks by means of the photo-electric cell was demonstrated. As usual the different instruments and equipment in this division were of great interest to many, who have listened in on their own radio sets to the Observatory time signals being broadcast through station CNRO.

A demonstration of experiments in light, which illustrated many astronomical phenomena, was conducted by Mr. N. A. Irwin, assisted by four students of the Glebe Collegiate Institute. Interesting experiments in the reflection, refraction, and composition of light, were shown. Probably the most spectacular demonstrations were those illustrating total reflection by means of a luminous cascade, and the scattering of white light by small particles. This latter experiment was exemplified by passing a beam of light through a glass tank containing a weak solution of hyposulphite of soda with the addition of dilute sulphuric acid. The blue of the sky was shown by the laterally emitted light, while the emergent beam changed in colour from yellow to red, and produced the colours observed at sunset.

In the Division of Stellar Photometry was an engine for measuring the diameters of star images on photographic plates. Of particular interest was a collection of transparencies showing the growth of astronomical work in Canada, from the early equipment of this institution to the huge reflector at Victoria. Other slides showed many of our celestial neighbours, from nearby ones to the distant spiral nebulae.

Various types of instruments used in work on Terrestrial Magnetism

were also shown and explained to the guests. These included dip-circles, magnetometers and earth-inductors with which measurements of declination, inclination and intensity are determined.

The Astrophysics Division was divided into two sections, one in the office on the second floor, the other in the large dome. The display in the office was solely relating to the recent discovery here of an object, suspected to be a new trans-Neptunian planet. The actual plates on which the object was photographed in 1924 were shown, and also enlargements of these. Still greater enlargements of two more restricted areas showed the motion of the body from February 7 to February 29.

In the dome the guests were shown some of our celestial wonders by means of the 15-inch telescope. Unfortunately clouds obscured the view for a large part of the evening, but many of the visitors were able to get an excellent view of our nearest neighbour, the moon.

M. S. Burland,
Secretary.

AT TORONTO

April 1.—The meeting was held in the Physics Building of the University of Toronto, Mr. J. R. Collins in the chair. An assistant Curator was appointed, Mr. Fred Troyer; and an assistant Recorder, Mr. S. C. Brown.

The Rev. James E. Kline, C.S.C., of the University of Notre Dame, Indiana, was elected to membership.

The speaker for the evening was Dr. H. R. Kingston, M.A., Ph.D., Preisdent of the Society, and the subject was "Eclipses, with special reference to those of the present month."

"Eclipses have interested people from time immemorial; among the ancients they spread superstition and terror, comets allying themselves with this phenomenon in spreading fear of punishment to come, in the form of pestilence, famine and other dire troubles. Happily to-day we are more enlightened on these matters, and welcome such phenomena for their scientific and spectacular interests, although even in these days superstition still prevails in some minds, as the more recent visits of Halley's comet would show. Record of eclipses date from early times. The Chinese record an eclipse of the sun in 2136 B.C., but the first actual prediction of an eclipse occurred in 585 B.C.

It was shown by the lecturer that it is possible to have a maximum of seven eclipses in one year, four of the sun and three of the moon, or five of the sun and two of the moon, with a minimum of two, both solar. Slides were used to illustrate the condition at certain times in which the moon would escape being eclipsed; thus in some years it is possible that no eclipse of the moon would occur.

Dr. Kingston referred to the two coming eclipses of this month, and the total eclipse of the sun in 1932, the latter being of especial interest to us in eastern Canada, owing to its close proximity, namely just east of Montreal.

The chairman voiced the appreciation of those present, and expressed regret

that Dr. Kingston found it necessary to curtail his most instructive lecture, owing to the pressure of time, due to the convening of a special council meeting.

The balance of the evening was taken up by a short talk on the constellation of Gemini, by Mr. S. C. Brown, and a few notes on observations by Mr. A. R. Hassard.

April 15.—The meeting was held in the Physics Building, Mr. J. R. Collins in the chair.

There was one election to membership. Mr. H. D. Benner, P.O. Box 520, City Hall Station, New York, was elected a member.

The speaker for the evening was Prof. H. A. McTaggart, M.A., and the subject, "Some Problems of Relativity in Physics", with experiments.

The lecturer mentioned that the inception of the use of the word "Relativity" was probably due to the study of the stars and their motions. The theory of Relativity is yet much misunderstood, and too literal translations of various hypotheses must be avoided, the fact that the physicist finds a measuring rod shorter in length when in motion, does not mean that it is actually shorter, but is the relative effect of moving bodies. It was found that when a beam of light is divided by reflecting half from a partly silvered mirror, allowing the other half to pass through, each beam then being passed through separate tubes in which water flowed in opposite directions, one beam is advanced and the other retarded, and when again united and examined, interference bands are seen. Further illustrations showed the extent to which the relativist is dependent upon the physicist's laboratory for proofs of his hypotheses. The relativist postulates that moving objects, when increasing speed, increase their mass, and experiments in physics bear this out. A quantum of light brought into collision with an electron, would be shot along a different path, and there would be a change in colour, due to the change in speed and mass. Experiments in physics show that the emission of light is probably due to an electron jumping from one orbit to another.

A sincere vote of thanks to the lecturer was moved by Dr. C. A. Chant.

Dr. Chant then discussed the latest reports as to the position, distance, speed and orbital revolution of the trans-Neptunian planet, and a slide was projected of a photograph, showing its close proximity to the star Delta Geminorum.

Mr. A. R. Hassard was called upon to describe the constellation Canis Minor, after which the meeting adjourned.

S. C. Brown, *Recorder.*

The Royal Astronomical Society of Canada

OFFICERS FOR 1930

Honorary President—J. S. Plaskett, B.A., D.Sc., F.R.S., Victoria, B.C.
President—H. R. Kingston, M.A., Ph.D., London, Ont.
First Vice-President—R. K. Young, Ph.D., Toronto.
Second Vice-President—Mgr. C. P. Choquette, M.A., Lic.Scs., Montreal.
General Secretary—Lachlan Gilchrist, M.A., Ph.D., 198 College St., Toronto.
General Treasurer—H. W. Barker, 198 College St., Toronto.
Recorder—E. J. A. Kennedy, Toronto.
Librarian—C. A. Chant, M.A., Ph.D., Toronto.
Curator—Robert S. Duncan, Toronto.
Council—D. S. Ainslie, M.A., Ph.D., London, Ont.; Napier Denison, Victoria, B.C.; Miss A. Vibert Douglas, Ph.D., Montreal; R. E. DeLury, M.A., Ph.D., Ottawa; R. A. Gray, B.A., Toronto; E. A. Hodgson, M.A., Ottawa; J. A. Pearce, M.A., Victoria, B.C.; J. Patterson, M.A., Toronto; John Satterly, M.A., D.Sc., Toronto; L. A. H. Warren, M.A., Ph.D., Winnipeg; and Past Presidents—Sir Frederic Stupart, F.R.S.C.; A. T. DeLury, M.A.; L. B. Stewart, D.T.S.; Allan F. Miller; J. R. Collins; W. E. W. Jackson, M.A.; R. M. Stewart, M.A.; A. F. Hunter, M.A.; W. E. Harper, M.A.; and the Presiding Officer of each Centre as follows—C. C. Smith, B.A., D.L.S., Ottawa; Dr. A. H. MacCordick, Montreal; L. A. H. Warren, M.A., Ph.D., Winnipeg; C. S. Beals, M.A., Ph.D., Victoria; H. R. Kingston, M.A., Ph.D., London, Ont.; J. A. Marsh, Hamilton.

TORONTO CENTRE

Honorary President—Sir Frederic Stupart
Chairman—J. R. Collins
Vice-Chairman—R. A. Gray, B.A.
Secretary—E. J. A. Kennedy
Treasurer—Miss Evelyn Watt
Recorder—J. R. Gibbs, F.R.M.S.
Observation Committee—Dr. C. A. Chant, J. R. Collins, A. R. Hassard, A. F. Hunter, Dr. D. B. Marsh.

OTTAWA CENTRE

President—C. C. Smith, B.A., D.L.S. *Vice-President*—J. S. Lane, B.A.
Secretary—Miss M. S. Burland, B.A., Dominion Observatory, Ottawa.
Treasurer—A. W. Grant, B.A.
Council—Dr. T. L. Tanton; Dr. C. F. Henroteau; N. A. Irwin, B.A.; and Past Presidents—R. M. Stewart, M.A.; R. E. DeLury, M.A., Ph.D.; R. J. McDiarmid, M.Sc., Ph.D.; C. R. Coutlee, C.E.; and H. M. Ami, D.Sc.

MONTREAL CENTRE

Honorary President—Mgr. C. P. Choquette
President—Dr. A. Howard MacCordick
First Vice-President—Dr. J. B. McConnell
Second Vice-President—Dr. Julian C. Smith
Secretary-Treasurer—Dr. A. V. Douglas, Physics Building, McGill University, Montreal.
Council—A. S. Eve, D.Sc., F.R.S.; H. E. S. Asbury; J. T. Armand; J. Lutrell; A. Browning; Miss J. Fleet; Justice E. E. Howard; Col. W. E. Lyman.

LONDON CENTRE

President—H. R. Kingston, M.A., Ph.D.
Vice-President—Mrs. S. J. Berry
Secretary-Treasurer—Dr. H. S. Wismer, 253 Queen's Ave.
Council—Rev. R. J. Bowen, F.R.G.S.; T. C. Benson; W. E. Saunders; E. H. McKone; Miss M. Callard.

WINNIPEG CENTRE

President—L. A. H. Warren, M.A., Ph.D.
Vice-President—N. J. MacLean, M.D., F.A.C.S.
Treasurer—J. H. Kolb
Secretary—Mrs. J. Norris, 569 Sherburn St.
Council—C. E. Bastin; D. R. P. Coats; A. W. Megget; Mrs. J. C. Howey; Rt. Rev. T. W. Morton; Mrs. E. L. Taylor.

VICTORIA CENTRE

Honorary President—W. E. Harper, M.A.
President—C. S. Beals, M.A., Ph.D.
First Vice-President—G. M. Shrum, M.A., Ph.D.
Second Vice-President—W. H. Gage, M.A.
Secretary-Treasurer—P. H. Hughes, 1218 Langley St., Victoria, B.C.
Council—J. P. Hibben; J. Goodfellow; G. A. Bucklin; W. T. Bridge; R. W Hunter; Mrs. M. A. Kelk; and Past Presidents—J. S. Plaskett, D.Sc.; F. N Denison; W. S. Drewry, C.E.; W. E. Harper, M.A.; James Duff, M.A.; P. H Elliott, M.Sc.; and J. A. Pearce, M.A.

HAMILTON CENTRE

President—J. A. Marsh; *Vice-Presidents*—Dr. W. R. Jaffrey, Rev. John Samuel, W. J. Hocking; *Secretary-Treasurer*—Miss Beatrice Marsh; *Recorder*—Miss J. I. Jackson; *Librarian and Curator*—T. H. Wingham; *Council*—J. J. Evel, Capt. C. P. Hardy, W. F. Mallory, Dr. Gordon M. Jackson, Miss Winnifred Parker, Miss E. J. Reynolds, W. T. Goddard, Chas. E. Bull, C. F. Marshall, R. Wynne, E. H. Darling.

THE ROYAL ASTRONOMICAL SOCIETY OF CANADA

The objects of the Society, incorporated in 1890, are:

(*a*) "To study Astronomy, Astrophysics and such cognate subjects as shall be approved of by the Society and as shall, in its opinion, tend to the better consideration and elucidation of Astronomical and Astrophysical problems; and to diffuse theoretical and practical knowledge with respect to such subjects.

(*b*) To publish from time to time the results of the work of the Society; and,

(*c*) To acquire and maintain a Library, and such apparatus and real and personal property as may be necessary and convenient for the carrying into effect of the objects of the Society."

For many years the Toronto organization existed alone, but now the Society is national in extent, having active Centres in Montreal, P.Q.; Ottawa, Ont.; Toronto, Ont.; London, Ont.; Winnipeg, Man.; and Victoria, B.C. Among its 800 members are a number of the leading astronomers and scientists of the world, many amateurs, and in addition, many laymen who are interested in the culture of the science.

Membership in the Society is open to anyone interested in Astronomy. The annual dues are $2.00; life membership $25.00 (no further dues).

The annual fee includes subscription to the publications.

The Society publishes a monthly JOURNAL containing about 500 pages of interesting articles, and the yearly HANDBOOK of 72 pages containing valuable information for the amateur observer. Single copies of the JOURNAL or HANDBOOK are 25 cents.

The Library and the Offices of the Society are at 198 College St., Toronto, Ont. Applications for membership, or for further information should be addressed to:

General Secretary—Dr. Lachlan Gilchrist, 198 College St., Toronto, Ont., or the Secretary of any Centre as given on the previous page.